Delivering the two degree global climate change target using a flexible ratchet framework

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Global climate negotiations have been characterized by a divide between developed and developing nations – a split which has served as a persistent barrier to international agreement within the United Nations Framework Convention on Climate Change process. Notable progress in bridging this division was achieved at the 21st Conference of the Parties meeting in Paris through the introduction of Intended Nationally Determined Contributions (INDCs). However, the collective ambition of submitted INDCs falls short of a global 2°C target, requiring an effective ratchet mechanism to review and increase national commitments. Inequitable distribution of additional responsibilities risks re-opening historic divisions between parties. This article presents a flexible ratchet framework which shares mitigation commitments on the basis of per capita equity in line with emerging requirements for a 2°C target. The framework has been designed through convergence between developed and developing nations; developed nation targets are based on an agreed standardized percentage reduction wherever emissions are above per capita equity; developing nations are required to peak emissions at or below per capita equity levels by an agreed convergence date. The proposed framework has the flexibility to be integrated with current INDCs and to evolve in line with shifting estimates of climate sensitivity.

1. Introduction

The failure of international negotiations to bridge the division between developed and developing nations (Barrett, 2005) has been a central criticism of the effectiveness of the UNFCCC process (Harris, 2007; Schiermeier, 2012; Brenton, 2013). The large variability in economic standing, stage of development and historical greenhouse gas emissions between nations has made international consensus increasingly challenging (Helm, 2008). The COP21 meeting in Paris represented a key turning point in the UNFCCC process; transition from a top-down to bottom-up target-setting approach through the submission of Intended Nationally Determined Contributions (INDCs) has been noted as a crucial factor in incorporating developing nations within mitigation commitments (Fawcett et al. 2015; Bodansky et al. 2014; Grubb, 2015). To date, INDCs covering 187 countries have been submitted (UNFCCC 2015b)—a clear signal of ubiquitous commitment to tackling climate change.

Despite the positive impact of the introduction of the bottom-up approach, collective INDCs are projected to result in a global average temperature increase of around 2.7°C by 2100 (van Renssen, 2015; Knutti et al. 2015), surpassing a 2°C (or 1.5°C) threshold (Schreurs, 2015). Two key additions to the Paris agreement - a ratchet mechanism targeting scale-up of efforts from current commitments and a five-year global stocktake of global emission pathways and projections (UNFCCC, 2015) - will prove crucial in closing this ambition gap.

It's suggested that a ratchet mechanism applied on an entirely voluntary, non-standardised basis is unlikely to mobilise the level of global effort required to meet a 2°C post-industrial warming target. As discussions turn towards which parties should be responsible for INDC scale-up, historic divisions in the negotiating positions of developed and developing nations are likely to re-emerge. This process will be more complex due to the heterogeneous nature of proposed INDCs—the use of different metrics on the basis of absolute emission, carbon intensity, and emissions below Business-As-Usual (BAU) pathways, in addition to inconsistency in base and target years, gives no rationale for comparison of equitable burden-sharing between nations (Ji & Sha, 2015).

To prove effective, a ratchet mechanism should: be globally all-inclusive without hindering necessary development needs (Wang et al. 2015); maintain a standardised approach; utilise a common emissions metric; be fair and equitable in

its share of responsibility (Lange et al. 2010; Althor et al. 2016); and be flexible enough to allow to integration with emerging understanding of climate sensitivity (Meinshausen et al. 2009) and periodic global emissions stocktakes (Freeman et al. 2015; Webster et al. 2012).

2. Outlining the framework

This article presents a ratchet framework based on the principle of global convergence towards per capita equity for any given pre-defined annual emissions level or scenario. Per capita emissions were selected as a common metric to ensure (and track) a fair basis for scale-up in ambition, and as a basis of differentiation in mitigation targets—this should ensure that development needs are not compromised by reduction commitments. In contrast to negotiating individual INDCs for 187 countries, the proposed framework offers a flexible, standardised approach with only four variables: emissions start/base year; target year of convergence; target annual GHG emissions; and level of ambition.

The conceptual basis of the framework is firstly outlined, before the provision of an example case of how this has been applied to reach convergence by 2040 in line with Representative Concentration Pathway (RCP) 4.5 (IPCC, 2014a)— a pathway which represents a stepwise increase in ambition from current INDCs. It should be emphasised that RCP4.5 is used as an example only; the merit in the proposed framework is in its easy adaptation to changing internationally and scientifically agreed parameter values.

2.1 Target-setting

Targets within the framework are defined towards global convergence for per capita equity. The intended year for when these convergence targets are to be achieved introduces the first variable parameter (*t*)—this could be 2030, 2035, or 2040, for example, and can be determined by general consensus or stocktake review. Per capita equity level is the second variable (x_e); this is set using the most robust UN population projections, and the required annual GHG emissions level for any RCP for the given target year. The required annual GHG emissions level can be set in line with any emissions scenario. This is an important degree of flexibility as it can be coupled with emerging scenario analysis (such as further IPCC reviews of 1.5°C and 2°C pathways), progressive scientific understanding and period global emissions stocktakes.

Within the framework nations are differentiated into two pools based on base year per capita emissions (x_b) relative to target year equity. This base year variable is consistently applied to all parties. Pool 1 nations are defined as those with base year per capita emissions above target year per capita equity levels. In other words, Pool 1 nations would need to reduce per capita emissions by the target year if equity was to be achieved. The framework target for Pool 1 nations is to achieve an agreed percentage reduction in per capita emissions above equity levels. This percentage reduction (*r*) is the final variable; the same percentage reduction is applied to all Pool 1 countries. Hence, each nation's level of effort is set based on its distance from per capita equity (Equation 1):

$$x_t = (x_b - x_e) * (100\% - r) + x_e$$

The level of percentage reduction would have to be globally agreed, credibly reflect the level of reductions needed to achieve the agreed global carbon budget, and maintain sufficient room for Pool 2 nations to grow/peak within this budget.

Pool 2 nations are defined as those with base year per capita emissions below target year equity ($x_b < x_e$). Targets for these nations are simpler: per capita emissions by the target year must not exceed equity (Equation 2):

$$x_t \leq x_e$$

To prevent the penalisation of developing nations marginally below the per capita equity level, Pool 2 nations are not restricted from surpassing this equity threshold in the interim as long as they have peaked and reduced back to equity levels by the target year. Setting this target year restriction, however, should discourage nations from peaking far beyond equity levels, with an understanding that this will

subsequently impose tougher reduction efforts. Pool 2 targets are designed as a balance between the variable development priorities that still exist, and with regard for the importance of developing nations' growth profiles in meeting a "safe" global budget.

2.2 Tracking progress

The profiles of nations' emissions within both pools will be varied. This makes it essential to outline an intended tracking mechanism to ensure nations are on-track and making sufficient progress towards the longer-term target (Knutti et al. 2015).

Countries within Pool 1 who have already reached peak emissions ("The Reducers") would be tracked based on period-specific linear reduction profiles; nations would be expected to report annual or multi-year reduction rates relative to those necessary to reach final targets.

The second group ("The Peakers") includes nations with per capita emissions above equity and that are currently still in a period of emissions growth - making a growth-peak-reduction profile necessary to reach their respective target. In this case progress would be tracked using a metric of Rate of Growth Reduction (ROGR) percentage ($\%yr^{-1}$)—the rate in reduction of GHG emissions growth required to meet its long-term target. This can be calculated based on base year per capita emissions, starting GHG growth rates, and target year per capita emission levels.

The final group of nations ("The Growers") are those with emissions below per capita. Sustainable development will be a key focus for this grouping—meeting necessary development needs while continuing to reduce the carbon intensity (CO_2eGDP^{-1}) of this progress. Tracking for these nations would be based on ROGR (as above) for nations expected to peak above equity, otherwise annual or multi-year carbon intensity reductions would suffice.

2.3 RCP4.5 Framework Example

To demonstrate how such a framework would function, an example iteration has been provided which falls in line with the RCP4.5 profile. The RCP4.5 scenario projects a global mean surface temperature increase of 2.4°C (likely range 1.7-3.2°C) from pre-industrial (assuming 0.6°C warming prior to the 1986-2005 reference period) (IPCC 2014a; IPCC, 2014b). RCP4.5 has been selected as it represents a stepwise scale-up in ambition from current INDC projections (although not yet sufficient for a 2°C target).

3. Methods

To model this framework, a key aspect of the methodology involved a standardisation of absolute emissions and future emission targets into a per capita metric**.** All national and global emissions data was therefore normalised in per capita terms using historical and projected population figures (detailing annual figures and projections from 1950-2100) as provided by the UN World Population Prospects (UN, 2013). This database provides three projected scenarios: high, medium and low fertility. This study applied population figures from the medium fertility scenario.

The methodology applied the two fundamental convergence target equations for Pool 1 and 2 nations respectively (Equations 1 and 2):

$$x_t = (x_b - x_e) * (100\% - r) + x_e$$

$$x_t \leq x_e$$

where x_t and x_b represents national per capita emissions in the target and base year respectively (measured in $tCO_2ecapita^{-1}$); x_e represents global per capita equity ($tCO_2ecapita^{-1}$) in the target year for the selected global GHG emissions target; and r represents the percentage reduction in emissions of levels above per capita equity (%).

2010 was selected as the base year on the basis of it being one of the latest full emission (total GHGs) inventory datasets with resolution to the national level for all UNFCCC parties. Base year emission figures were sourced from published World Resources Institute (WRI) production-based accounts (WRI, 2014). x_b was thereby given by dividing each party's 2010 total emissions by 2010 UN population figures. The convergence target year was defined as 2040—when mapped on a per capita basis, 2040 marks a turning point from GHG stabilisation profile into a steep global reduction effort.

IPCC RCPs were converted into per capita equity pathways by dividing annual GHG emissions for each by the projected global population in every given year. RCP4.5 was selected as the framework pathway which represents a bridging stepwise increase in ambition from current INDC proposals.

Nations were split into their respective pools based on 2010 emissions relative to 2040 per capita equity (Pool 1 countries are those above target equity, and Pool 2 below). To define parameter r for Pool 1 targets, its value was adjusted and resultant x_t figures for key nations (primarily the USA on the basis of its past failure to ratify Kyoto, the EU and China) compared relative to their submitted INDCs. By finalising an r value, x_t could therefore be calcualted for all Pool 1 nations.

2040 per capita emissions for Pool 2 nations were x_e. However, it was expected that not all Pool 2 nations will realistically reach this level of emissions given current and projected growth trends (despite being free to do so within framework targets). To balance expected emissions from Pool 1 and 2 to ensure they collectively fall below the 54.0 $GtCO_2e$ budget (with the opportunity to increase the value of r if required), expected Pool 2 emissions were estimated using economic growth and carbon intensity reduction assumptions. Regional growth trends were applied to all Pool 2 nations using average regional economic growth rates derived from World Bank data (World Bank 2014), and carbon intensity reduction rates proposed within national INDCs. A CO_2e growth rate for each region was calculated using these assumptions and applied as an annual constant growth between 2010-2040 to derive expected 2040 emissions. If this value exceeded x_e, x_e was taken to be 2040 emission levels; if below x_e, the calculated value was assumed instead.

The additional component of the methodology did not affect 2040 targets or global GHG budget, but acted to serve as a tracking mechanism for peaking nations. In this regard, the constant Rate of Growth Reduction (ROGR) required for peaking nations to reach their 2040 target was calculated. To do so, starting per capita GHG growth rates in 2010 for individual peaking nations were calculated using WRI accounts, and annual ROGR rates ($\%yr^{-1}$) adjusted until 2040 emissions fell in line with framework targets.

4. Results

Following the RCP4.5 emissions scenario, 2040 convergence year emissions equate to global annual GHG emissions of 54.0 $GtCO_2e$. When corrected for 2040 population - 9.04 billion based on medium-fertility UN population projections - this equates to per capita equity of 5.97 $tCO_2e\ capita^{-1}\ y^{-1}$ (herein rounded to 6.0 $tCO_2e\ capita^{-1}\ y^{-1}$ for simplicity). This defines parameter x_e.

The percentage reduction above per capita equity required for Pool 1 nations (value r) was selected to be 85% for this scenario. The rationale for selecting this figure was twofold. Firstly, we attempted to closely align it with current INDC proposals from key emitting nations (the USA primarily, then cross-checked with implications for EU28, China and India targets). Rationalising the USA's INDC commitments to a per capita basis resulted in a close fit to an 85% reduction target above per capita equity within the proposed framework. Secondly, this figure has been set based on the analysis of the level of collective Pool 1 reduction necessary to allow for expected growth in Pool 2 nations from projected economic trends. Pool 1 country reduction trajectories were analysed first, adjusting required levels of reduction, and balancing with the remaining target year GHG budget to test whether this allowed for agreeable, projected rates of growth in Pool 2 nations.

Targets for Pool 1 nations were therefore given by Equation 3:

$$x_{2040} = (x_{2010} - 6.0) * (100\% - 85\%) + 6.0$$

With targets for Pool 2 nations defined by Equation 4:

$$x_{2040} \leq 6.0$$

Projected emission profiles for parties within each of the example framework groupings are given in Figures 1a-c, with a combined framework overview in Figure 2. When normalised to a per capita metric, these figures are a close fit to the submitted INDCs of many of the top emitting nations with the exception of the EU28. The EU's submitted INDCs extend beyond what would be required based on per capita equity.

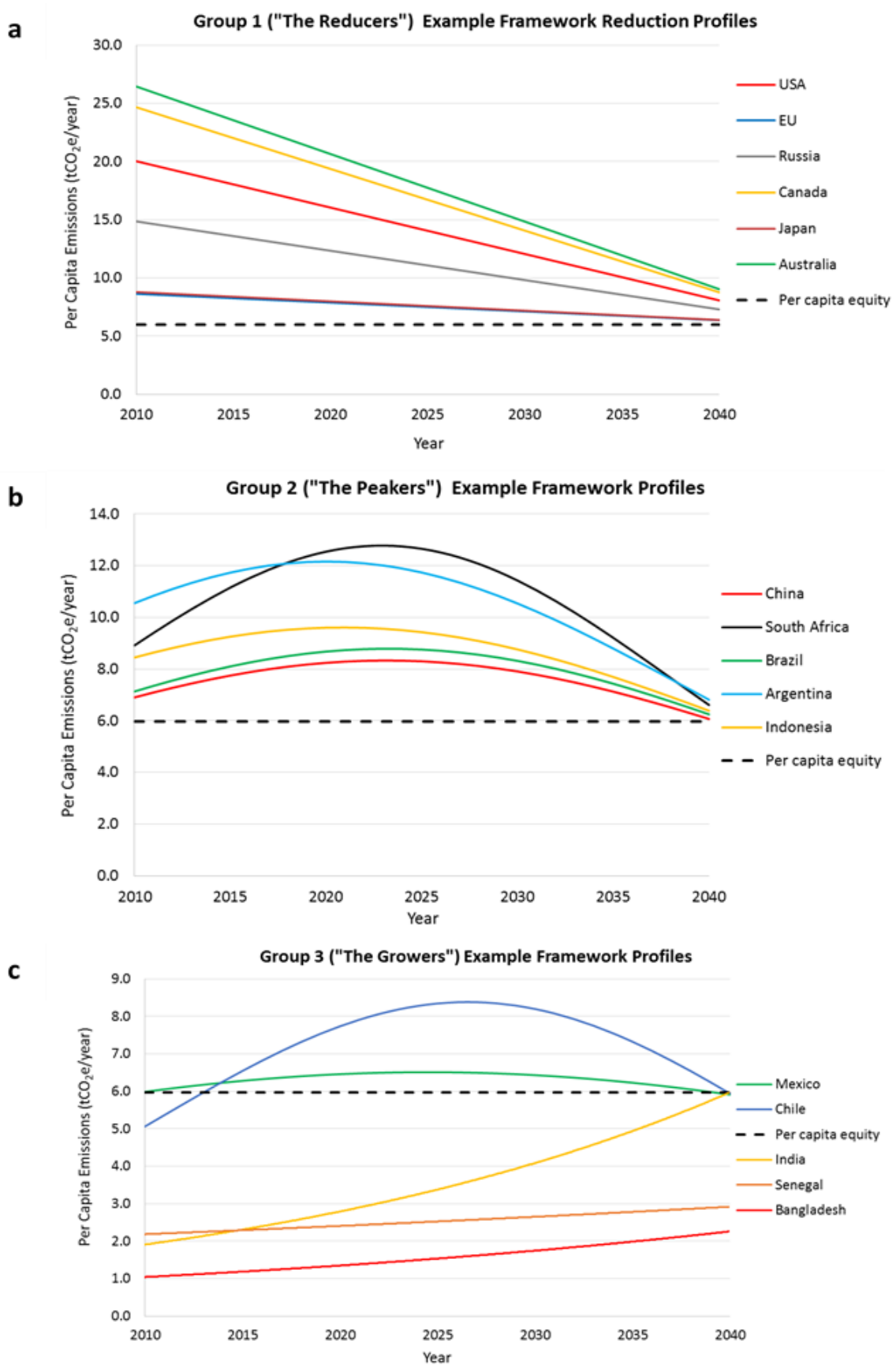

Figure 1: Example national per capita GHG emission profiles for achievement of respective 2040 convergence targets for representative countries (2010-2040)
a, Linear reduction profiles for Group 1 ("The Reducers") nations
b, Growth-peak-reduction profiles for Group 2 ("The Peakers") nations assuming a constant required Rate of Growth Reduction (%yr^{-1}) to reach 2040 per capita targets
c, Projected growth profiles of Group 3 ("The Growers") based a 2040 equity-level cap of 6.0 tCO_2e $capita^{-1}$ yr^{-1} and projected emission growth based on regional economic and carbon intensity assumptions

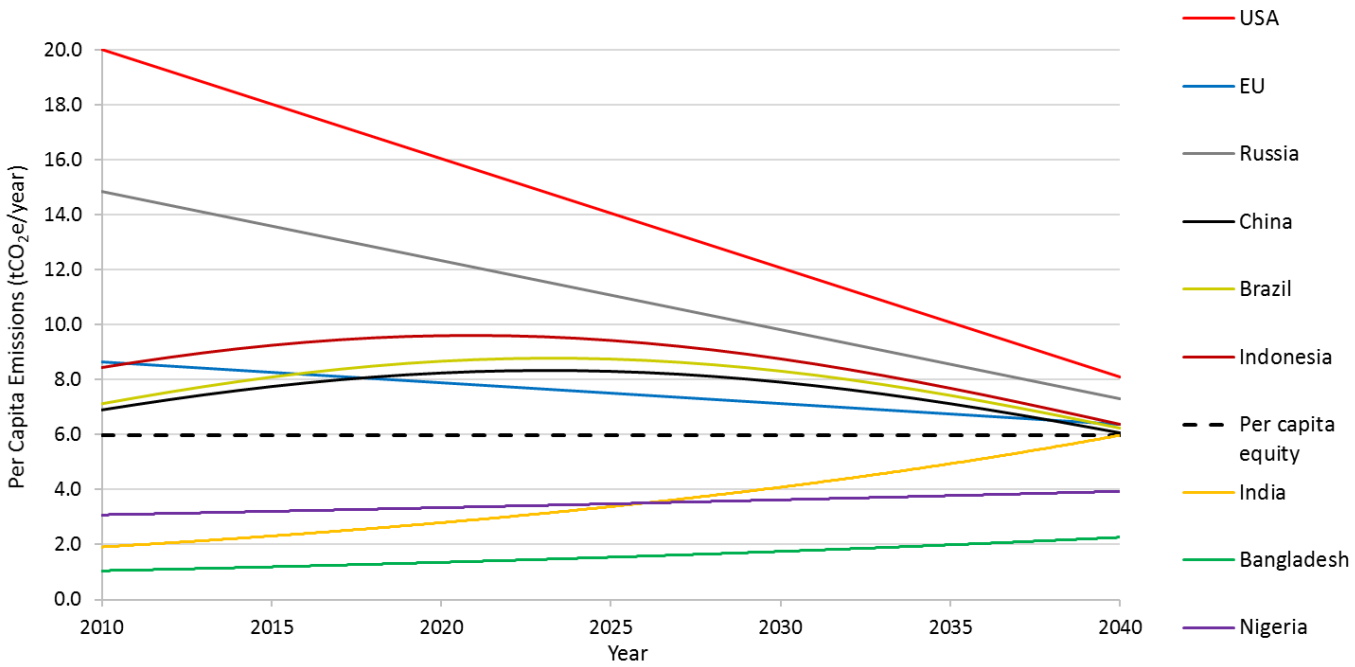

Figure 2: Combined convergence-phase national profiles of representative parties based on framework targets for convergence towards per capita equity in 2040, based on RCP4.5 annual GHG emissions.

To ensure the combination of Pool 1 and Pool 2 emissions did not exceed the 2040 global GHG budget, per capita emissions/targets were multiplied by population projections for absolute emissions. Within this example, collective GHG emissions were calculated to be 50.0 $GtCO_2e$—below the 54.0 $GtCO_2e$ target, leaving some budget for missed targets and uncertainties in actual Pool 2 national growth rates.

The outlined convergence framework forms the first stage in a two-stage process towards global decarbonisation. Its fundamental role is in bridging the climate policy gap between developed and developing nations, allowing for necessary development in a way that falls in line with required global mitigation scenarios. This convergence profile still leaves a significant gap in the level of global emissions reduction needed to remain close to a 2°C trajectory. The contraction phase of action would begin following the target year (2040 in this case). This would entail ubiquitous linear reduction profiles, with a new target year (*f*) and per capita equity level (x_f) in line with the selected emission mitigation scenario requirements. For example, in the case of RCP4.5, this was calculated to be 2.2 $tCO_2ecapita^{-1}$ by 2080 (shown in Figure 3), giving a target defined in Equation 5:

$$x_{2080} \leq 2.2$$

It's proposed that distinguishing the pathway of global decarbonisation as a two-stage process (convergence then contraction) is important in a number of aspects. This is in contract to other equity-based models, such as Contraction and Convergence (C&C) which aim to combine the two in a single stage (Meyer 1996). Firstly, it's considered important to define a distinct period of emissions convergence prior to contraction in order to distribute a fair share of effort based on current emissions inequity, and allow for necessary development needs for currently low per capita emitting nations. Secondly, especially when normalised to a per capita level, a stepwise reduction process could serve as an important engagement tool for individuals. Especially for nations with high per-capita emissions levels, defining the framework on a long-term one-stage contraction phase to comparably very low per-capita levels could act as a key disincentive for short-term action. Differentiating this full process into shorter-term, more manageable target points could potentially help to facilitate wider engagement in individual footprint reduction. Thirdly, a focus on initial convergence and progress towards more equitable distribution in emissions—largely closing the developed-developing divide which currently exists—could potentially facilitate stronger global cooperation between parties. This reduction in party divisiveness could be crucial in effective mitigation in the later stages of decarbonisation when more drastic mitigation action may have to be implemented.

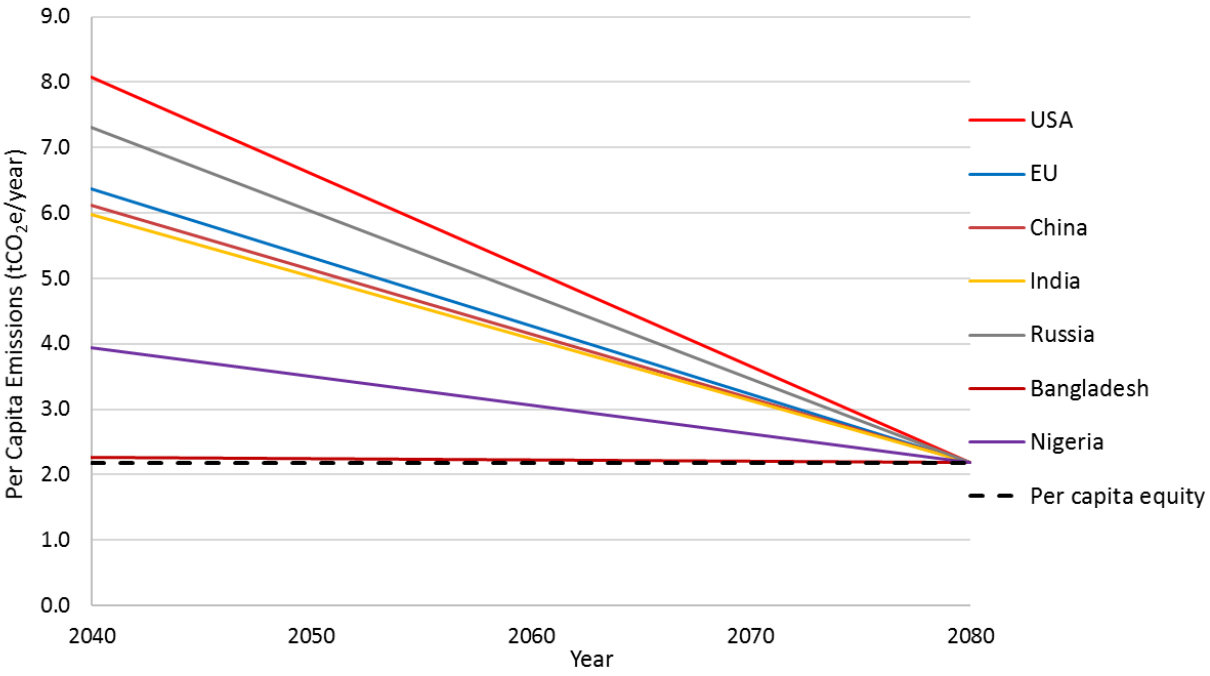

Figure 3: Post-convergence contraction phase (2040-2080) defined by ubiquitous per capita targets of equity at 2.2 tCO_2e $capita^{-1}$ yr^{-1} in line with RCP4.5 GHG annual emissions profile.

5. Discussion

5.1 Functionality as a ratchet mechanism

The implementation of the INDC submission process has been highlighted as an important factor in reaching an inclusive agreement at the COP21 meeting in Paris (Fawcett et al. 2015; Bodansky et al. 2014; Grubb 2015). The transition from a top-down to bottom-up target-setting approach marks an important turning point within the UNFCCC process. Its success therefore has to form an important consideration in discussions surrounding a potential ratchet mechanism, or similar policy tool. The framework proposed here aims to integrate with and build upon the success of the INDCs, rather than reverting back to a fully top-down policy framework.

The proposed framework utilises current INDC submissions; by normalising to a per capita metric, submitted targets would form base-year national emissions. The wide adoption of the COP21 agreement by UNFCCC parties suggests that the majority of members are agreeable to the share of responsibility of mitigation targets currently standing within the INDCs. This could allow for the INDCs to serve as an agreeable starting basis for any ratchet mechanism.

The proposed framework therefore serves to act as an equity-based ratchet, scale-up approach based on current, rather than historic contributions (with considerations made for future development needs). The flexibility of target year and emissions budget within the framework allows for targets to be incrementally increased through the five-year stocktake review process. The level of scale-up can therefore be tightened with each review, based on an evolving understanding of remaining carbon budgets and progress attained within the preceding target period.

The crucial component within this scale-up is its ubiquity; all parties scale INDCs in line with a globally agreed target year, budget and reduction ambition. The robustness of the proposed framework serves to eliminate potential divisions, especially in light of on-going uncertainties around precise climate sensitivity. For example, if a stage were reached whereby it was recognised that a rapid scale-up in ambition was needed to avert catastrophic climate change, divisions would likely appear between parties who had already progressed in scale-up of their INDCs, and those who had chosen to delay until later within the commitment period. How this necessary uptake of additional responsibility would be shared could lead to further breakdown in global cooperation. Periodic scale-up within a ratchet mechanism

therefore needs to be handled in an inclusive, unified way to avert such future divisions.

At present there has been minimal discussion on how the proposed ratchet tool within the COP21 agreement could be managed. As the situation currently stands, INDC scale-ups are expected to occur on an entirely voluntary basis. However, considering current projections based on INDC mitigation predict a global average post-industrial temperature increase of around 2.7°C by 2100 (van Renssen 2015; Knutti et al. 2015), a notable increase in ambition is necessary to limit global average temperature increase to 2°C. It has been widely recognised throughout the UNFCCC process, as with many collective action challenges, that the tendency to free-ride is a key barrier to effective and inclusive international action (Barrett & Stavins 2003). It could be expected, therefore, that in an agreement where further action is entirely voluntary, nations will tend to delay or even refuse to increase target ambitions. This in turn serves as a disincentive for other parties within the agreement to do so. In this regard, it seems unlikely that the level of scale-up will be sufficient to meet collective targets to limit average temperature increase to 2°C.

The proposed framework therefore attempts to strike an important balance between the success of the bottom-up approach of the INDCs with a cooperative, equitable rationale for periodic increases in ambition.

The framework, at present, does not specify a penalty for non-compliance. It is expected that if such a framework were adopted as a ratchet mechanism, its ubiquity, in addition to its equity-based rationale, could serve as important pressures within the international community. The outlined emphasis on inclusivity, with no parties exempt from mitigation responsibilities, makes it more challenging for parties to withdraw from obligations on the grounds of unfair differentiation - such as occurred within previous agreements (Grubb 2015).

At present, the option of trading credits within the framework has not been included. This does not rule out possible introduction of a trading flexibility, however a number of issues would have to be overcome to prove effective. One of the key aims of the framework is to simplify a target-setting process that currently has a high level of complexity, with no standardised basis for tracking or comparison. The introduction of trading permits within the framework would undoubtedly add an additional layer of

complexity. A second issue could arise in the allocation of trading permits for "grower" parties—these parties do not have a prescribed level of growth, which could prove challenging in the distribution of defined credits. Finally, a number of issues have arisen from the allocation of permits within a ratchet mechanism process. If we consider the European Union's Emissions Trading Scheme (EU ETS) as one model of a ratchet mechanism, with gradual reduction in allowances through each commitment period, we observe a number of challenges in allowance allocation—these have been widely discussed within the literature (IETA 2015; Weishaar 2007). An important challenge would arise in the carry-over of emissions allowances between ratchet periods, especially in the case that carbon budgets (and therefore per capita target levels) were amended within the flexibility mechanism of the framework.

5.2 Political feasibility

Political feasibility of adoption and party acceptance, in addition to a framework's effectiveness, must form an integral part of policy analysis. Some aspects of political feasibility and how the proposed framework would operate as an agreeable ratchet mechanism have been discussed in section 5.1.There are two key components which would need to be politically considered: the somewhat top-down nature of the proposed framework, and the equity-based principle of target-setting.

In reiteration of discussion above, it is recognised that the bottom-up approach of the INDCs has been pivotal in reaching success in the COP21 Paris agreement. This has been an important transition from the former top-down approach taken within the Kyoto Protocol, and failure of agreement in Copenhagen—an approach that has proven largely ineffective and politically contentious (Bodansky 2010). A challenging divide therefore arises: a completely voluntary bottom-up approach is unlikely to prove effective in reaching the level of ambition necessary for a 2°C target; meanwhile a top-down regime has historically been politically unpopular. Interestingly, and in contrast with perceived support for the INDC approach, studies have shown that the least favourable principle for distributive responsibility in the climate regime has been the "voluntary principle" (Hjerpe et al. 2011)—a result that raises further doubt in the effectiveness of an entirely voluntary ratchet mechanism.

An important consideration for the proposed framework was to therefore develop a semi-hybrid option, whereby the INDC submissions were integrated with a flexible

top-down approach. A key political resistance to previous top-down approaches has been a focused pressure on a certain sub-sect of parties. Within the Kyoto Protocol, the largest contention by developed parties was the exemption of developing nations from mitigation commitments (Brenton 2013). Moving forwards to the COP15 meeting in Copenhagen, emphasis rapidly shifted towards developing nations (most notably China, India, and Brazil)—a pressure that was perceived to be unjust, with little regard for development needs or equitable economic opportunity. In both cases, the key resistance to top-down target-setting was its exclusivity in pressure, either on developed, or on major developing nations. This led to the classic developed-developing divide which has been a defining barrier in previous discussions (Brenton 2013).

The framework presented here has been developed to attempt to overcome these divisive issues, most notably by making it all-inclusive: all parties within the UNFCCC would have defined mitigation targets, in line with current development needs and per capita contribution. Although party groupings have been discussed within the framework, these do not operate as the previous “annexe” system did within the Kyoto Protocol (Robert & Hagel 1997); their main purpose is to serve as an illustration of how the trajectories of parties in different stages of development may evolve within the framework targets. The other notable difference in the proposed approach from previous top-down regimes is that the target parameters within the framework would be internationally agreed and adopted within COP discussions. Although carbon budgets would be derived and informed by the scientific community, the choice of percentage reduction above per capita equity levels, for example, would be an internationally-agreed and adopted parameter. It’s likely that reaching consensus on such values could prove challenging, however, these discussions could greatly simplify COP discussions; discussions which will become increasingly complex in debating the scale-up of 180-190 unique and heterogeneous targets. Nonetheless, the adopted targets within the framework would be based on collective ambition, rather than top-level prescription of necessary reduction targets.

Another important consideration for political feasibility is the use of an equity-based principle. The role of equity in shared responsibility has previously been a highly contentious feature of the climate regime (Caney 2009). However, it has been recognised that equity and fairness principles between negotiating parties can greatly enhance international cooperation. Beyond its benefits for collective

agreement, equity forms a vital component of ensuring development needs can be met alongside mitigation responsibility. There have been a number of proposed equity-based principles, such as the egalitarian, sovereignty, polluter-pays, or ability-to-pay rule—each with specific preferences from different stakeholder groups (Lange et al. 2010). Developing nations—especially the major developing economies, who have come under intense international pressure on emissions mitigation policies—would be likely to support a ratchet framework centred on the notion of per capita equity. Developed nations have historically been much more resistant to equity-based principles, most notably those with a high-degree of emphasis on historic responsibility.

Studies which have focused on the relative support and opposition to different equity-based principles have found that developed nations are significantly more supportive of egalitarian and sovereignty principles, than polluter-pays or ability-to-pay rules(Lange et al. 2010). The proposed framework implements an egalitarian (the principle of equal per capita emissions) approach—potentially the most politically feasible of all the equity principles. Political acceptance was a key consideration in selection of an egalitarian approach. Additionally, it was considered essential to develop a mechanism which standardised targets using a common, comparable metric which could be communicated effectively down to the individual level. This made a per capita based approach the most obvious choice.

While the proposed framework would inevitably face some resistance within the international community, it has been designed in such a way as to strike an important balance between the fundamental contentions which have served as a key barrier in previous discussions. The integration of both bottom-up and top-down approaches could be an important factor in ensuring that collective action is not only politically accepted, but is also effective in reaching a sufficient level of ambition. The selection of an egalitarian-based equity principle was chosen to not only to allow scope for development in low per-capita emitting countries, but also in recognition that of all the equity-based approaches, this was the least politically divisive, and most agreeable for both developed and developing nations.

5.3 Utility as a tracking tool

The framework, as outlined, has been proposed as a policy tool for adoption as a possible ratchet mechanism within international negotiations. However, it’s

understood that its adoption, as with any global framework, would prove challenging. Regardless of whether it's implemented or not, it could prove useful as a key tracking tool for measurement of how fair and equitable party scale-up of INDCs are within the ratchet process.

By normalising INDC targets to a per capita basis and setting as base year emissions, the framework calculation process could be reversed; parties' percentage reductions above per capita equity could be tracked through each stocktake/ratchet period. This could serve as a key comparison for how scale-up responsibilities were shared between nations on the basis of per capita equity. This holds potential in going beyond its capacity as a tracking tool by also putting international pressure on those parties who were failing to meet their responsibilities as defined through a fair per capita metric. In this regard it could serve as a valuable tool for increasing ambition, even if not fully adopted as a keystone policy tool within the UNFCCC process.

6. Conclusion

Effective progress within the UNFCCC process has been hindered to date by the divisiveness between developed and developing nations—most notably controversy surrounding distribution of mitigation responsibility. This was partly bridged at the COP21 negotiations in Paris through the introduction of the INDC submission process. However, the proposed voluntary basis of the ratchet mechanism for step-up in national commitments signals a key threat to reaffirming historical divides. It's unlikely that commitments necessary for a global mitigation target of 2°C will be reached through an open, voluntary basis alone.

This paper has outlined a standardised framework to the ratchet mechanism—a framework based on the principle of global convergence towards per capita equity. As previously discussed, the modelled iteration of the outlined framework is provided only as an example of how it could be implemented. Its merit lies in its flexibility to be adjusted in line with international agreement on each of the variable parameters, and evolving scientific understanding. For example, it could offer an effective option for a standardised approach to the ratchet mechanism. In this case, submitted INDCs re-rationalised on a per capita basis could serve as base year emissions, offering a standardised approach to closing the current ambition gap between 2 and 2.7°C of post-industrial warming. The necessary target year and correlated per capita equity

level to achieve this could be defined based on the most up-to-date emission scenarios. The five-year stocktake review process agreed in Paris in December 2015(UNFCCC 2015a) offers the opportunity to track progress and potentially re-adjust on a globally consistent basis in light of emerging clarity.

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